(54) Title: APPARATUS FOR BIDIRECTIONAL DATA AND UNIDIRECTIONAL POWER TRANSMISSION BETWEEN MASTER AND SLAVE UNITS USING INDUCTIVE COUPLING

(57) Abstract

Data communication apparatus comprises a master unit (2) and at least one physically separate, passive slave unit (4). The master unit (2) has a first part (29) of an inductive communication system, and a processor (20) connected to the first part of the inductive communication system. The slave unit has a second part (40) of the inductive communication system, a data store (48), and a modulator (44, 49) responsive to data from the data store and connected to the second part (40) of the inductive communication system. The first and second parts of the inductive communication system (29, 40) are constructed so that when the slave unit (4) is brought into proximity with the master unit (2), power is inductively coupled from the master unit to the slave unit via the inductive communication system. The modulator (44, 49) in the slave unit (4) is thereby activated to cause data from the store (48) to be inductively communicated from the slave unit (4) to the master unit (2) via the inductive communication system. The processor (20) is responsive to the data supplied to the master unit (2).

APPARATUS FOR BIDIRECTIONAL DATA AND UNIDIRECTIONAL POWER TRANSMISSION BETWEEN MASTER AND SLAVE UNITS USING INDUCTIVE COUPLING

The invention relates to a data communication apparatus of the kind comprising a master unit and at least
5   one physically separate, passive slave unit. The invention is concerned particularly, but not exclusively, with toys and games.

A number of electronic toys and games exist in which information cards or pieces are placed on a base, which
10   base reads information off the pieces and provides an output such as verbal messages. A difficulty is that the base only contains a preprogrammed memory and can only perform the tasks it is made to do.

US-A-5190285 describes an electronic game having a
15   base and separate playing pieces or characters, each character containing a store for storing data which can be transferred to a processor attached to the base. The character is supplied with power via coils in the character and base respectively and communicates the data through a
20   coupled capacitor plate. This is a relatively complex construction and in practice the use of capacitive coupling will result in very weak signals being transferred which is undesirable.

In accordance with the present invention, data
25   communication apparatus comprises a master unit and at least one physically separate, passive slave unit, the master unit having a first part of an inductive communication system, and a processor connected to the first part of the inductive communication system, and the
30   slave unit having a second part of the inductive communication system, a data store, and a modulator responsive to data from the data store and connected to the second part of the inductive communication system, wherein the first and second parts of the inductive communication
35   system are constructed so that when the slave unit is brought into proximity with the master unit, power is inductively coupled from the master unit to the slave unit

2

via the inductive communication system, and the modulator in the slave unit is thereby activated to cause data from the store to be inductively communicated from the slave unit to the master unit via the inductive communication
5   system, the processor being responsive to the data supplied to the master unit.

With this invention, the inductive communication system is utilized both for supplying power to the slave unit and for receiving data from the slave unit. This
10   results in a simpler construction, particularly for the slave unit.

In principle, any RF inductive communication system could be used but in the preferred arrangement, the inductive communication system comprises a tuned circuit.
15   The use of a tuned circuit maximises power transfer and the phase change detected as well as increasing the selectivity of the apparatus so that a slave unit will only pass data to the master unit when they are in close proximity.

In this case, the modulator is preferably adapted to
20   adjust the resonant frequency of the tuned circuit in accordance with data supplied from the data store. Effectively, the inductive arrangement defined by the tuned circuit is either tuned or detuned in accordance with the data. Detuning the system can be detected as a phase shift
25   in the received signal relative to the drive signal fed to the tuned circuit by the processor.

In the preferred arrangement the processor generates a drive signal, at a drive frequency, which is fed to the first part of the tuned circuit, the tuned circuit being
30   adapted to resonate at a frequency offset from the drive frequency when no data is being transmitted to the master unit, such that the tuned circuit resonant frequency is phase shifted relative to the drive frequency. The advantage of this offset is that in the case of binary
35   data, whichever value the binary data has, there will be a phase shift in the received signal.

3

Typically, the frequency offset will be small, no more than 5%, preferably no more than 3.5%, of the resonant frequency of the drive frequency.

Typically, the modulator is responsive to binary data from the data store either to adjust or not to adjust the resonant frequency of the tuned circuit in accordance with the value of the data.

Conveniently, where the resonant frequency of the tuned circuit is offset from the drive frequency, the non-adjusted and adjusted resonant frequencies of the tuned circuit are on either side of the drive frequency. This provides a symmetrical arrangement which enhances detection.

It will be understood that the use of a phase change yields good noise immunity, comparable to FM modulation, in contrast to known amplitude modulation techniques.

In principle, the data stored in the data store could be fed directly to the modulator but in some cases this could introduce difficulties where successive digits have the same value leading to a DC level. To overcome this, preferably, the slave unit comprises a unit for converting each binary digit from the store into a two bit sequence in which the values of the bits are different, the order within the sequence varying depending upon the value of the binary digit from the data store. The converting unit could comprise, for example, an exclusive - OR gate.

This approach ensures that every binary digit received from the data store causes a variation in the manner in which the tuned circuit is modulated. For example, a binary value 1 from the data store could be converted to a sequence "10" while a binary value "0" could be converted to "01".

Typically, the modulator comprises a switch for including one or more reactive elements into the tuned circuit, such as an additional capacitor. Conveniently, the modulator comprises a field effect transistor.

4

As previously mentioned, the master unit conveniently further comprises a phase comparator which receives a signal at the drive frequency, and the signal returned from the tuned circuit and generates an output signal related to
5   the phase difference between the two input signals.

Typically, the master unit will also further comprise a converter unit connected to the output of the phase comparator for generating a pulse width modulated signal related to the phase difference defined by the signal
10   output by the phase comparator. The converter unit could comprise an exclusive - OR gate as is known in the art.

The data stored in the data store can define a variety of types of information. For example, the data could define a programme to which the processor in the master
15   unit responds. Typically, however, the master unit includes at least one output device adapted to generate one or more of an electrical, visual, audible and mechanical output under control of the processor, in response to data received from the slave unit.

20   It will be appreciated that the invention is particularly suited for use as a toy or game, the or each slave unit being incorporated in a toy character, model or card. The advantage of this is that a common master unit can be provided for use with a variety of toys or models
25   each of which stores data related to the particular toy or model. For example, if the slave unit is incorporated in a toy character, the data stored in the data store may define an audio message intended to be the character speaking.

30   The invention has advantages for a toy manufacturer. One main advantage is that a user can acquire in the first instance a base containing the master unit and one set of pieces, each containing a respective slave unit, which together form one toy. But once a user is in possession of
35   a base, a new toy can later be made by supplying a new set of pieces with different information in their respective data stores. Thus for example a first toy might consist of

5

a base and a plurality of pieces in the form of well known
cartoon characters which convey verbally to the user their
name. The manufacturer could then supply different pieces
such as models of different aeroplanes which could be
5   provided in their respective data stores with a brief
verbal description about their history. It is also
envisaged that the information in the data store might form
a programme to programme the processor, in the master unit.
A toy might thus include one piece which programmes the
10   processor to form the basis of the actions of the toy, and
other pieces (which have less information in their
respective data stores) could then be read by the processor
once programmed. The processor could then become more
sophisticated and cause mechanical actions to take place in
15   addition to or as an alternative to audible and visual
outputs.

In further arrangements, the processor could be linked
to a further computer to form more complex toys. It should
also be noted that although the invention has particular
20   application to toys and games, it could also form part of
an educational aid.

In other applications, the Tag could be used to
provide information about an object, such as a file, to
which it is attached. For security applications, the Tag
25   could store a sample of the bearer's voice for comparison
with the bearer and/or information only known to the
bearer. Many other audio/musical applications are
possible.

In general the data store will be a ROM but in some
30   cases a reprogrammable store could be used.

Two examples of toys incorporating a data
communication apparatus according to the invention will now
be described with reference to the accompanying drawings,
in which:-

35   Figure 1 is a perspective view from above of a first
example of the toy;

6

Figure 2 is a block circuit diagram of the primary components in the base unit shown in Figure 1;

Figure 3 is a circuit diagram showing the components within the character of Figure 1; and,

5   Figure 4 is a view similar to Figure 1 but of a second example.

Referring to Figure 1 there is shown a toy having a base unit 1 in the form of a rectangular housing moulded, for example, out of plastics. On the upper surface 2 is a
10   recessed portion 3 trapezoidal in shape to receive a corresponding trapezoidal base 4a of a piece in the form of a character 4 e.g. a cartoon or other fictitious character. The base 4a and recess portion 3 are trapezoidal so that the base 4a only fits into the recess portion if it is
15   orientated into the correct position.

Inside the base portion 4a of character 4 is a Tag 5 including a slave unit defined by an electronic circuit shown in more detail in Figure 3. The Tag 5 is remotely activatable from energy transmitted thereto and, when
20   activated, transmits information contained in its memory.

Mounted inside the base unit 2 is a master unit shown in more detail in Figure 2. The master unit includes a Tag reader, part of which is shown at 6 in one corner of the recessed portion 3. The Tag reader is connected to a
25   speaker 7 and display 8. Batteries (not shown) may be used to power the reader speaker 7 and display 8, which batteries may be housed in the base unit 1.

In use of the device of Figure 1, the character 4 is placed in the recess portion 3 on surface 2 of the base
30   unit 1. The Tag 5 will thus lie adjacent the part 6 of the reader 6. The Tag 5 contains information about the character in for example compressed speech form which is read by the reader. This information is then displayed visually on display 8 and/or speech is transmitted through
35   speaker 7. Such information could include a brief story about the character or the character's name and what it does for example.

7

It is envisaged that the base unit 1 could be fabricated and sold with one or more characters. The owner could then purchase or otherwise acquire different characters each with the ability to convey different
5   information.

The components of the Tag reader are shown in more detail in Figure 2. The reader comprises a microprocessor 20 powered from batteries (not shown) along a power line 21. The microprocessor 20 is connected to the display 8
10   and the speaker 7 and, although not shown in Figure 1, may also be connected to a mechanical actuator 22 and an I/O interface 23 for connection to a remote computer (not shown). The microprocessor 20 is controlled via software stored in a memory 24. The microprocessor generates a
15   clock signal on a line 25 at a rf frequency, e.g. 16MHz, which is fed to a divider circuit 26 which reduces the frequency of the signal to 125kHz. This drive or "carrier" signal is filtered in the filter 27 and amplified by an amplifier 28 before being fed to a first part 29 of a tuned
20   circuit. The first part 29 of the tuned circuit includes a capacitor 30 and a 25 turn inductor 31. In this example, the capacitor 30 has a value of 39.8nF.

The circuit 29 is connected to one input of a phase comparator 32, the other input of which receives the
25   carrier frequency on a line 33. The comparator 32 compares the phases of the two input signals and generates a binary output signal whose state corresponds to the determined phase difference. This signal is fed to a converter circuit 34, typically in the form of any exclusive-OR gate
30   which converts the input signal into a pulse width modulated (PWM) signal which is fed to the microprocessor 20. The microprocessor 20 responds to that signal to control one or more of the speaker, display, actuator and I/O interface 7,8,22,23.
35   Figure 3 illustrates the components within the character 4 defining the slave unit. The circuit comprises a second part 40 of the tuned circuit, formed by a 25 turn

8

inductor 41 and a capacitor 42 having a value in this
example of 28.8nF. The circuit 40 is connected in series
to a further capacitor 43 having a value of 3300pF and in
parallel with a FET 44. The output from the circuit 40 is
5   connected to a rectifying circuit 45 formed by two diodes
and a capacitor which generates a DC power signal of 5V for
use by the other components within the slave unit. It
should be noted that the slave unit has no internal power
source of its own.

10   The output from the circuit 40 is also fed to a
divider arrangement 46 of conventional form from which a
clock signal (typically 16Kbits/sec) is derived which is
fed to the clock input 47 of a serial ROM 48 and to one
input of an exclusive-OR gate 49. Data is clocked out of
15 an output 50 of the serial ROM 48 at half the clock rate
and is fed to the other input of the exclusive-OR gate 49.
The output from the exclusive-OR gate 49 is fed to the gate
of the FET 44.

        When the character 4 is brought into proximity with
20 the recess 3, the part 6 of the Tag reader (corresponding
to part or all of the coil 31) will be brought into
proximity with the coil 41 and the tuned circuit comprising
the first and second parts 29,40 will be completed. The
resonant frequency of the tuned circuit is slightly
25 different from that of the carrier or drive signal so that
the comparator 32 will detect a phase difference between
the two. Following conversion of this phase difference by
the converter 34 to a PWM signal, the state output by the
comparator 32 will be detected by the microprocessor 20.
30 The microprocessor 20 will then momentarily inhibit
generation of the carrier frequency to allow the slave unit
within the character to reset following which the carrier
frequency is restarted.

        On re-start, power will be coupled from the reader to
35 the Tag via the tuned circuit and will be rectified by the
rectifying circuit 45 so as to generate a 5V supply. The
alternating signal generated by the tuned circuit will also

be fed to the divider 46 from which the clock is obtained
causing data to be clocked out of the serial ROM 48. Since
the data is clocked out of the serial ROM 48 at half the
clock rate, each data bit applied to the exclusive-OR gate
5   49 will remain applied while the other input of the
exclusive-OR gate 49 receives two clock signals of
complementary value. Thus, the output of the exclusive-OR
gate 49 will be two bits either "01" if the data bit on the
input 50 is a "0" or "10" if the data bit on the line 50 is
10   a "1".

The output from the exclusive-OR gate 49 is fed to the
gate of the FET 44 with a value of "1" turning the gate on
and a value of "0" turning the gate off. When the gate is
turned on, the capacitor 43 will be effectively inserted
15   into the tuned circuit thus increasing its resonant
frequency slightly below the frequency of the carrier,
while if the output from the exclusive-OR gate 49 is a
binary "0" then the gate of the FET 44 will remain closed
and the tuned circuit will resonate at its normal
20   frequency, slightly more than that of the carrier.

The resonant frequency of the tuned circuit will thus
vary in phase relative to the input carrier from the
amplifier 28, depending upon its resonant frequency, the
difference in phase between the two conditions (binary "1"
25   and binary "0" from the exclusive-OR gate 49) being
typically about 30°.

The difference in phase is detected by the comparator
32, as explained above, and a signal is generated by the
comparator 32 defining the phase difference which is fed to
30   the converter 34 which in turn generates a pulse width
modulated signal which is fed to the microprocessor 20.

The response of the microprocessor 20 to the signal
from the converter 34 will depend upon the type of
information being transmitted. Typically, the serial ROM
35   48 will contain header information which is initially
downloaded to the microprocessor 20 and this will define
the type of data which is to follow, for example programme

data, display data, audio data or the like. The microprocessor 20 responds to the header information by processing the following data as appropriate.

If the following data defines a programme then it will be fed, if necessary after further modification by the microprocessor 20, to the memory 24 for storage, following which the microprocessor 20 will carry out the stored programme.

If the data defines audio information, for example it may comprise compressed audio data, the microprocessor 20 will decompress the data and then apply appropriate control signals to the speaker 7 which will generate an audio message.

If the data defines display information, typically in compressed form, the microprocessor 20 will decompress that data and convert it into suitable control signals (for example R, G, B signals) which are then applied to the display 8 which typically comprises a monitor.

If the data comprises mechanical movement data, the microprocessor 20 will generate from it suitable control signals which are fed to the actuator 22. The actuator 22 may be connected to an arm or signal or the like.

In addition the data may be at least temporarily stored.

Instead of the pieces being in the form of characters or models, they could simply be cards or other objects incorporating slave units. In such an instance the recessed portion 3 on surface 2 might take a different form to accommodate the cards. It is pointed out that it is not essential for the surface of the base unit 1 to have a recess portion to receive the pieces. Thus, as shown in Figure 4, the base unit 2A has no recess, the Tag Reader part 6A being positioned under the surface of the base unit. Also it is not essential for the reader to be adjacent and in close proximity to the Tag in a piece in order for the reader to interface with the Tag. The reader and Tag could be distanced apart, for example by up to 2cm.

In a further application, the game could involve a ball and goal, a slave unit incorporated in the ball and a master unit in or adjacent to the goal. When the ball passes into the goal, data is transmitted to the master unit which will thus detect a goal scored and optionally generate relevant information obtained from the slave unit store.

The master unit could also include its own data which is used to control one or more of the output devices either separately from or with data from the slave unit.

12

CLAIMS

1. A data communication apparatus comprising a master
unit and at least one physically separate, passive slave
unit, the master unit having a first part of an inductive
communication system, and a processor connected to the
first part of the inductive communication system, and the
slave unit having a second part of the inductive
communication system, a data store, and a modulator
responsive to data from the data store and connected to the
second part of the inductive communication system, wherein
the first and second parts of the inductive communication
system are constructed so that when the slave unit is
brought into proximity with the master unit, power is
inductively coupled from the master unit to the slave unit
via the inductive communication system, and the modulator
in the slave unit is thereby activated to cause data from
the store to be inductively communicated from the slave
unit to the master unit via the inductive communication
system, the processor being responsive to the data supplied
to the master unit.

2. Apparatus according to claim 1, wherein the inductive
communication system comprises a tuned circuit.

3. Apparatus according to claim 2, wherein the processor
generates a drive signal, at a drive frequency, which is
fed to the first part of the tuned circuit, the tuned
circuit being adapted to resonate at a frequency offset
from the drive frequency when no data is being transmitted
to the master unit, such that the tuned circuit resonant
frequency is phase shifted relative to the drive frequency.

4. Apparatus according to claim 3, wherein the resonant
frequency of the tuned circuit is offset by up to 3.5% from
the drive frequency.

5. Apparatus according to any of claims 2 to 4, wherein
the modulator is responsive to data from the data store
selectively to adjust the resonant frequency of the tuned
circuit.

6. Apparatus according to claim 5, wherein the modulator is responsive to binary data from the data store either to adjust or not to adjust the resonant frequency of the tuned circuit in accordance with the value of the data.

7. Apparatus according to claim 6, when dependent on at least claim 3, wherein the non-adjusted and adjusted resonant frequencies of the tuned circuit are on either side of the drive frequency.

8. Apparatus according to any of claims 5 to 7, when dependent on claim 3, the master unit further comprising a phase comparator which receives a signal at the drive frequency, and the signal returned from the tuned circuit, and generates an output signal related to the phase difference between the two input signals.

9. Apparatus according to claim 8, further comprising a converter unit connected to the output of the phase comparator for generating a pulse width modulated signal related to the phase difference defined by the signal output by the phase comparator.

10. Apparatus according to any of the preceding claims, wherein the data store contains binary data, the slave unit further comprising a unit for converting each binary digit from the store into a two bit sequence in which the values of the bits are different, the order within the sequence varying depending upon the value of the binary digit from the data store.

11. Apparatus according to claim 10, wherein the converting unit comprises an exclusive - OR gate.

12. Apparatus according to any of the preceding claims, wherein the modulator comprises a field effect transistor.

13. Apparatus according to any of the preceding claims, wherein the master unit includes at least one output device adapted to generate one or more of an electrical, visual, audible and mechanical output under control of the processor, in response to data received from the slave unit.

14

14. Apparatus according to any of the preceding claims, wherein a number of slave units are provided, each slave unit storing different data in its data store.

15. Apparatus according to any of the preceding claims in the form of a toy or game.

16. Apparatus according to claim 15, wherein the slave unit is provided in a toy character or model or a card.

17. Apparatus according to claim 16, wherein the master unit is provided in a base adapted to receive the character, model or card.

18. Apparatus according to claim 17, wherein the base includes a recess shaped to receive the character, model or card.
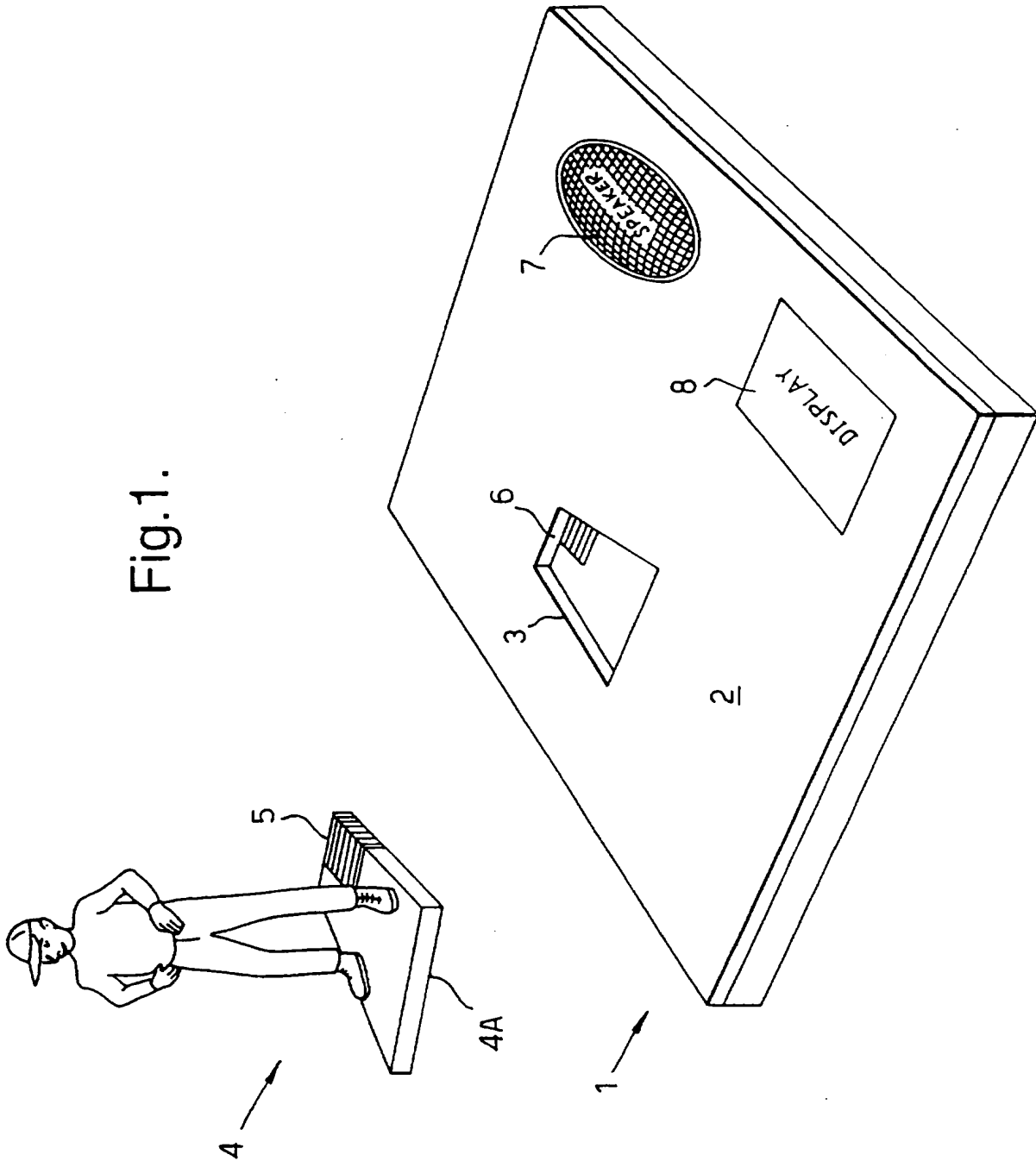
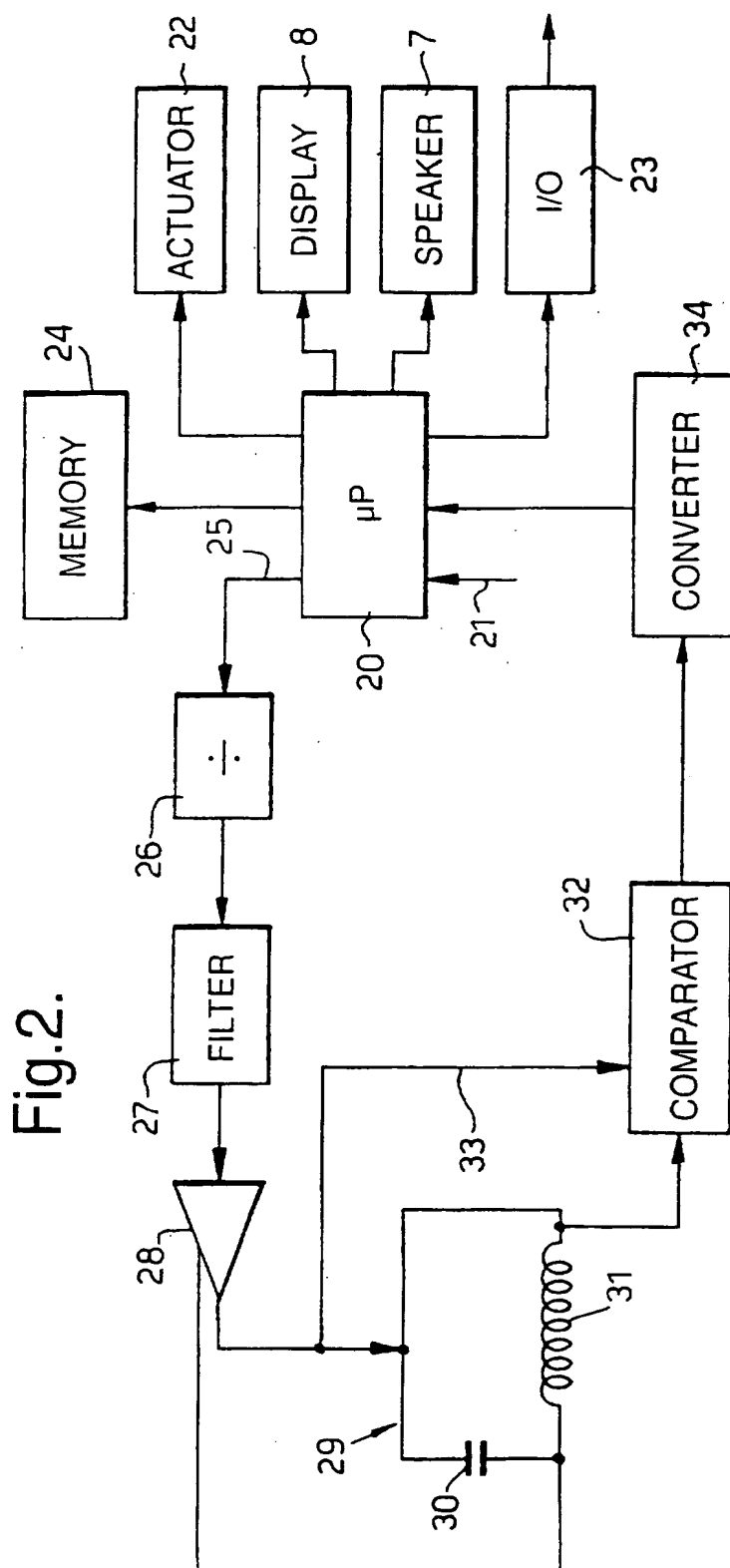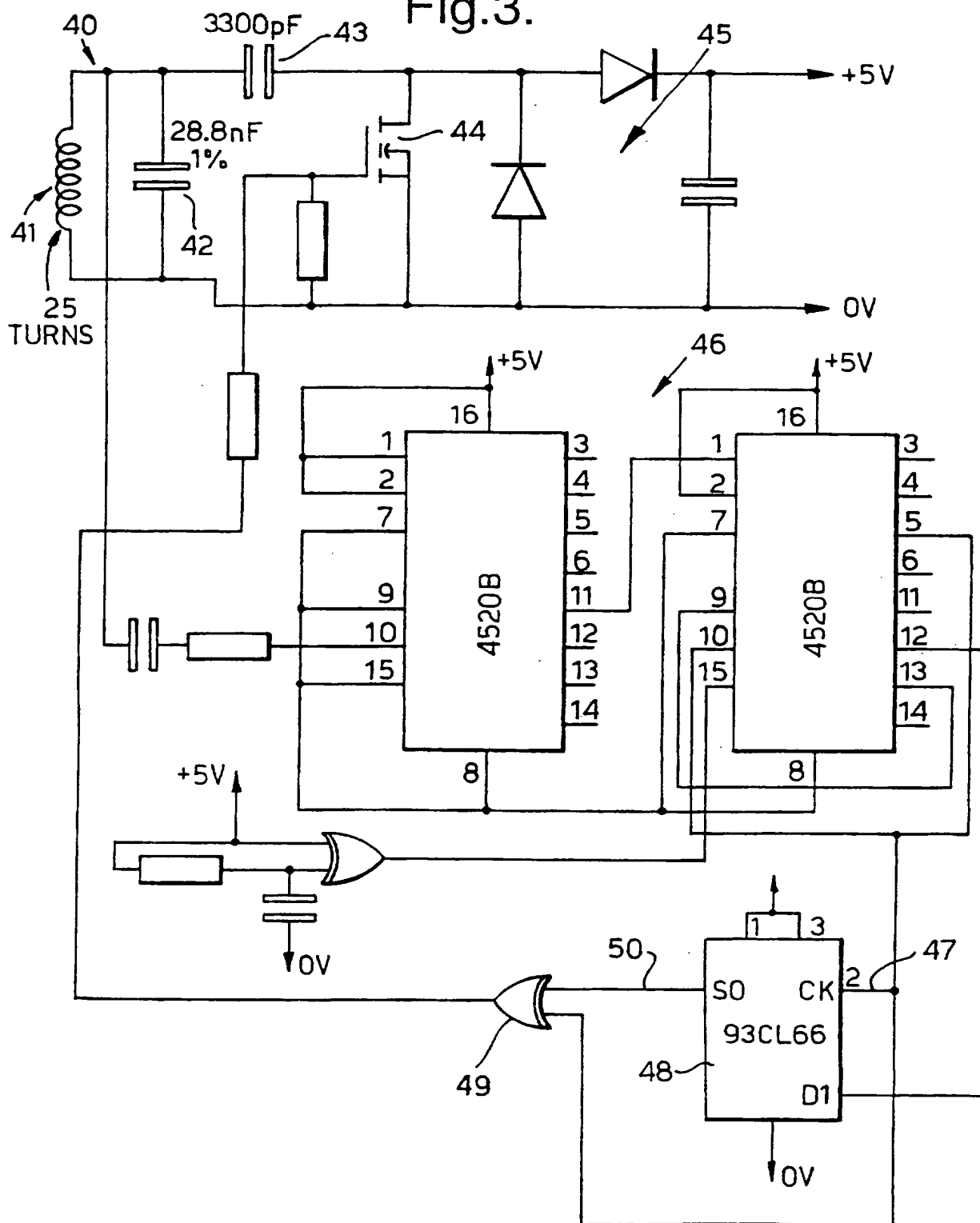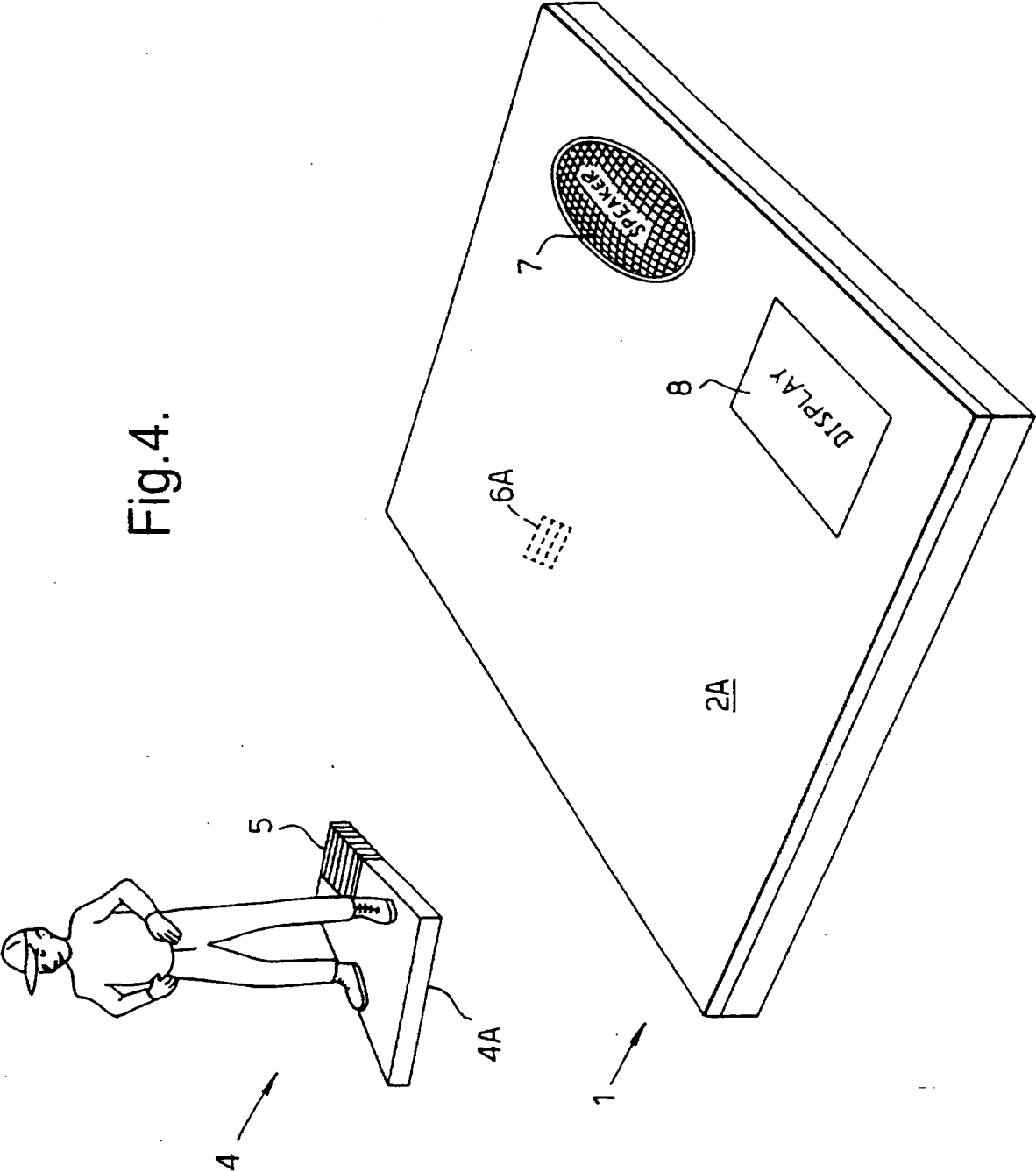# Fig.1.

2 / 4

Fig.2.

Fig.3.

Fig.4.

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6   H04B5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6   H04B   G06K   G01R

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 455 315 A (MARS INC) 6 November 1991	1-3,12, 14
Y	* Abstract *	13,15-18
	see column 1, line 32 - column 2, line 17	
	see column 3, line 41 - line 55	
	see column 4, line 44 - line 56	
	see column 5, line 21 - line 45	
	see column 6, line 17 - line 21	
	see column 9, line 56 - column 10, line 57	
	see column 11, line 33 - line 39	
	see column 14, line 50 - line 58	
	see claim 1	
	see figure 3	

	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 April 1997	17. 04. 97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	Lopez Marquez, T

Form PCT/ISA/210 (second sheet) (July 1992)

page 1 of 2

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5 190 285 A (LEVY ROBERT B ET AL) 2 March 1993 * abstract * see column 1, line 41 - column 2, line 19 see column 2, line 42 - column 2, line 55 see column 3, line 42 - column 4, line 8 see column 6, line 17 - column 6, line 37 see claim 1 see figures 1,6 ---	1,10,11, 13,15-18
Y	GB 2 232 851 A (DAIMLER BENZ AG) 19 December 1990 see page 2, line 1 - line 17 see page 3, line 9 - page 4, line 3 see page 6, line 16 - line 22 see claim 1 see figure 1 ---	1,10,11
A	US 5 184 001 A (LEVIONNAIS PHILIPPE) 2 February 1993 see column 1, line 6 - line 18 see column 2, line 10 - line 30 see column 7, line 41 - column 8, line 17 see column 8, line 67 - column 9, line 10 see column 9, line 52 - line 68 see claim 1 -----	2,3,12

2

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP 0455315 A	06-11-91	AU	581196 B	16-02-89
		AU	3633484 A	13-06-85
		BR	8406225 A	01-10-85
		CA	1240056 A	02-08-88
		DE	3485776 A	23-07-92
		EP	0147099 A	03-07-85
		GB	2153128 A,B	14-08-85
		GB	2187019 A,B	26-08-87
		GB	2187020 A,B	26-08-87
		GB	2187021 A,B	26-08-87
		HK	19593 A	19-03-93
		HK	19693 A	19-03-93
		JP	4211891 A	03-08-92
		JP	3282695 A	12-12-91
		JP	60153589 A	13-08-85
		US	4926996 A	22-05-90
		US	4674618 A	23-06-87
US 5190285 A	02-03-93	JP	7275522 A	24-10-95
GB 2232851 A	19-12-90	DE	3912497 A	18-10-90
		FR	2646035 A	19-10-90
		IT	1239776 B	15-11-93
		JP	3072752 A	27-03-91
		JP	6103894 B	14-12-94
US 5184001 A	02-02-93	FR	2640830 A	22-06-90
		DE	68910788 D	23-12-93
		DE	68910788 T	31-03-94
		EP	0374018 A	20-06-90
		ES	2048309 T	16-03-94
		JP	2264525 A	29-10-90
		US	5083013 A	21-01-92